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THE ECONOMICS OF CLEAN WATER. SUMMARY OF ANALYSIS

Environmental Protection Agency
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SUMMARY OF ANALYSIS

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ENVIRONMENTAL PROTECTION AGENCY
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SUMMARY OF ANALYSIS

Purpose and Scope

This report represents the fifth in the series of clean water reports to the Congress prepared in accordance with the Section 26(a) of the Federal Water Pollution Control Act, as amended. It studies the problem of water pollution and its control by giving an assessment of the prevalence and degree of water pollution occurring nationally and by giving estimates of the capital investment and annual operating requirements through 1976 in both the industrial and municipal waste treatment sectors. This analysis is based on assumptions of current federal-State water quality standards.

An assessment of the economic costs of the various treatment levels necessary to insure water quality standards up to zero discharge is also included.

Costs and Planned Investment

Industrial--Capital Expenditures

The costs (in billions of 1971 dollars) of the components of the level of industrial waste treatment as of 1968 are:

Total capital required to meet water quality standards		$8.1
Available capital stock as of 1968		$3.9
Industrial treatment	$2.4	
Public waste treatment serving industry	$1.5	
Unmet capital demands as of 1968		$4.1
Unmet capital demands as of 1971		$3.0

These figures are presented in Table 1 broken down by industrial category. Capital requirements are distributed through the various manufacturing sectors in a manner that strongly reflects their water use characteristics and has only a slight correlation with output values. Chemical manufacturers, primary metals production, pulp and paper production, petroleum refining, and food processing account, respectively, for 27 percent, 18 percent, 17 percent, 12 percent and 11 percent of the indicated investment, and 29 percent, 32 percent, 15 percent, 9 percent, and 5 percent of reported water intake. That there is a concentration of water use within industries is shown by the fact that 85 percent of the capital requirement associated with water pollution abatement comes from only a little more than a third of values added by manufacturers.

These figures are current as of 1968 and are only an approximation because data are reported on industrial investment in a manner that will not permit direct correlation with the calculations made in this report. The $3.9 billion of works-in-place as of 1968 appears to represent about 50 percent of the waste treatment required by water quality standards with, however, enormous variation in degree of compliance to be found between one industry and another.

The above figure (cf. Table 1) of $8.1 billion to cover capital requirements dictated by current interpretations of water quality standards was obtained by use of an industrial cost model. Industrial waste treatment costs are dependent on flow volumes, residuals characteristics, waste segregation opportunities, and available technology. Such considerations are generalized for industrial categories and then evaluated on the basis of reported flows and flow to cost relationships, in order to calculate treatment costs for such treatable discharge. Such treatment costs may

TABLE 1

INDUSTRIAL WASTE TREATMENT SITUATION SUMMARY, 1968

SIC	INDUSTRY	MILLIONS OF 1967 DOLLARS					
		Capital Supplied		Median		Maximum	
		By Industry	Publicly	Requirement	Deficiency	Requirement	Deficiency
20	Food & Kindred Products	193.8	315.3	913.3	404.2	997.5	488.4
22	Textiles	48.8	63.6	234.8	122.4	251.4	139.0
24	Lumber & Wood Products	9.7	2.3	115.8	103.8	186.1	174.1
26	Paper & Allied Products	529.5	79.3	1235.6	626.8	1550.5	941.7
28	Chemicals & Allied Products	343.2	191.5	867.6	332.9	2436.8	1902.1
29	Petroleum & Coal	342.1	7.1	817.4	468.2	1096.1	746.9
30	Rubber & Plastics	3.0	22.7	82.9	57.2	96.0	70.3
31	Leather	17.0	17.3	86.5	52.2	86.8	52.5
32	Stone, Clay & Glass	20.0	22.0	156.5	114.5	182.3	140.3
33	Primary Metals	216.3	125.9	1089.8	747.6	1620.5	1278.3
34	Fabricated Metal Products	6.7	51.4	99.9	41.8	124.1	66.0
35	Machinery	14.8	48.8	80.7	17.1	100.1	36.5
36	Electrical Equipment	23.8	92.2	113.5	(2.5)	129.5	13.5
37	Transportation Equipment	17.4	92.3	79.8	(12.5)	122.7	13.0
	Manufacturing	1787.0	1131.7	5964.2	3045.5	8965.7	6047.0
	(1971 dollars)	(2425.0)	(1535.7)	(8093.4)	(4132.7)	(12166.4)	(8205.8)

vary greatly depending on the efficiency with which abatement procedures are applied in any given plant, even within an industry. Although the most likely level of capitalization is about $8.1 billion, it could be as high as $12.2 billion.

In the eventual resolution of the industrial waste handling situation, it is not likely that the maximum investment of $12.2 billion will occur under existing abatement requirements. The association of capital requirements with water use practices has enormous implications for the dimensions of ultimate costs. Higher treatment costs, other things being equal, are a direct consequence of wasteful use of water. And water is wasted largely because it has had many of the characteristics of a free good. Imposition of a wastewater treatment requirements--or other cost-incurring constraints on water utilization--will, it has been demonstrated both in theory and in practice, lead to production practices that are less water-intensive, and thus have lower associated waste treatment values.

Several modifications of the evaluation model were attempted in order to arrive at a realistic assessment of capital requirements. One took into account the modification of water utilization practices that accompanies installation of waste treatment as well as hardware and construction costs. Without altering the relationships among treatment process components, water use coefficients were substituted for the observed ones--though all substitutions were made by recourse to observed conditions--and investment and annual cost calculations were produced to reflect the altered variables. The most likely investment level ($8.1 billion) is thought to be the one associated with "median" efficiency.

The breadth of the range of values contains some significant policy implications. These should be taken into account in any resolution of the waste handling problem:

1. Alternative approaches to waste reduction can produce similar efficiencies within a wide range of costs. Flexibility in approach to the issue should reduce the burden of water pollution abatement on the economy, freeing resources for other uses.

2. Accepting the general rule that management will not act to reduce its discharge of pollutants in the absence of external pressures, very direct incentives that embody water quality goals without specifying the means to reach them should provide an approach to a least-cost solution of the waste treatment question. Suitably scaled taxes on amount of waste discharge constituents or limits on allowable pollutant concentrations in the effluent, for example, should prove to be more effective than regulatory specification of treatment procedures.

3. Because the very wasteful users of water in any industry/region component strongly influence the mean, a relatively few factories--the most inefficient plants in the least efficient regions--account for a very considerable portion of the total cost of water pollution control. That concentration of avoidable costs in a few establishments suggests that

factory replacement may in more than a few instances be the most rational solution to waste treatment requirements. The fact that waste treatment does not represent a significant capital burden in the aggregate should not be allowed to obscure the subordinate fact that a number of plants may be scheduled for closure and replacement as a consequence of the very uneven distribution of such costs.

Industrial--Annualized Costs

The initial capital cost of facilities represents less than a fourth of the total cost of industrial waste treatment. Once installed, facilities must be operated and maintained. Given the composition of the set of treatment requirements evaluated here, operation and maintenance accounts for 35 percent of the annual cost. Interest, at current rates, accounts for a large share of annual charges for waste treatment. Some 40 percent of the annual costs of the modelled treatment system, and 27 percent of the annual costs of the system of works that industry reported to be in operation in 1968, can be attributed to interest payments implicit in the value of the capital stock. And to make the sequence of major and minor replacement expenditures required to sustain the stock of physical capital, the firm faces a continuing capital demand, one that is estimated to equal the capital cost within a 20-year period, and to account for 25 percent of the annual costs of the modelled system of waste treatment works. The annual costs (operation, maintenance, debt service, and replacement) associated with the $8.1 billion capital investment requirement is $1.6 billion. The annual cost associated with the higher $12.2 billion figure is $2.4 billion.

The projected cash outlays associated with attainment of effluent standards over the years 1968-1976 that manufacturers must anticipate is $20 billion (1971 dollars) (cf. Table 2). While incremental annual costs will probably amount to only about 0.2 percent of aggregate values added by manufacturers, up to 4 percent of total capital spending of some industries will be required to comply with standards, and as much as 1 percent of values added in some industries (pulp and paper, steel) will be added by waste treatment costs. If such costs were absorbed, the incremental costs in 1968 would have reduced the pre-tax profits of manufacturers by 0.9 percent. However, as seems more likely, if additional costs are passed on to consumers, with full maintenance of margins, prices of manufactured goods may increase by 0.1 percent.

Municipal--Capital Expenditures

The estimated total cost of constructing waste treatment facilities planned through FY 1976 and needed to meet current water quality standards or enforcement requirements is $18.1 billion, (cf. Table 3) according to a survey conducted by EPA. However, a lower estimate of $14.3 billion of required investment to achieve water quality standards by 1976 resulted from the Waste Treatment Facilities Evaluation model (cf. Tables 4 and 5).

TABLE 2

PROJECTED CASH OUTLAYS ASSOCIATED WITH ATTAINMENT
OF DISCHARGE STANDARDS BY 1976
(MEDIAN EFFICIENCY)

MILLIONS OF 1967 DOLLARS

SIC	Industry	OUTLAYS, 1968-1976 Net Investment	Growth	Replacement	Interest	Operations	Total	Total 1971 Dollars
20	Food & Kindred Products	722	189	302	474	413	2,100	2,850
22	Textiles	186	82	84	131	77	560	760
24	Lumber & Wood Products	99	-*	28	44	26	197	267
26	Paper & Allied Products	856	145	410	641	591	2,643	3,587
28	Chemical & Allied Products	324	572	432	671	729	2,728	3,702
29	Petroleum & Coal	475	55	282	439	265	1,516	2,057
30	Rubber & Plastics	80	38	29	45	36	228	309
31	Leather	70	18	29	45	29	191	259
32	Stone, Clay, Glass	138	27	48	75	108	396	537
33	Primary Metals	873	560	421	659	917	3,430	4,655
34	Fabricated Metal Products	93	48	36	56	70	303	411
35	Machinery	66	5	24	37	48	180	244
36	Electrical Equipment	90	34	40	62	83	309	419
37	Transportation Equipment	62	13	26	40	59	200	271
	Manufacturing Total	4,134**	1,786	2,191	3,419	3,451	14,981	20,329
	(1971 Dollars)	(5,610)	(2,424)	(2,973)	(4,639)	(4,683)	(20,329)	
	Maximum Cost Total	5,430	1,845	2,520	3,939	4,637	18,609	
	(1971 Dollars)	(7,369)	(2,504)	(3,420)	(5,345)	(6,292)	(25,252)	
	Minimum Cost Total	1,416	880	1,267	1,976	1,792	7,322	
	(1971 Dollars)	(1,922)	(1,194)	(1,719)	(2,669)	(2,432)	(9,936)	

*Rate of improvement in water productivity is greater than rate of growth of output.
**Does not account for publicly supplied waste treatment.

TABLE 3

SURVEY RESULTS OF ESTIMATED CONSTRUCTION COST OF SEWAGE TREATMENT FACILITIES PLANNED FOR THE PERIOD FY 1972-1976

(Millions of 1971 Dollars)

	FY-1972	FY-1973[1]	FY-1974[1]	FY-1975	FY-1976	Total
TOTALS	5,278.2	6,080.0	3,198.2	2,236.5	1,289.3	18,082.2
Alabama	33.5	9.6	9.5	7.9	5.1	65.6
Alaska	4.1	26.4	2.3	7.5	--	40.3
Arizona	10.7	8.9	--	6.2	1.4	27.2
Arkansas	12.5	27.7	11.3	10.0	--	61.5
California	280.4	930.9	218.4	369.0	340.8	2,139.5
Colorado	23.3	14.4	8.4	30.0	6.1	82.2
Connecticut	96.2	95.1	53.5	--	--	244.8
Delaware	7.8	8.8	79.0	2.5	5.6	103.7
Dist.of Columbia	62.7	40.9	--	--	--	103.6
Florida	313.0	125.7	89.4	106.3	17.0	651.4
Georgia	36.3	89.6	15.8	--	12.6	154.3
Hawaii	15.0	28.5	4.6	24.1	--	72.2
Idaho	15.7	8.6	7.4	.3	.4	32.4
Illinois	336.7	332.5	240.8	382.9	38.7	1,331.6
Indiana	161.3	207.2	121.7	22.1	27.6	539.9
Iowa	16.8	78.8	72.7	21.8	7.2	197.3
Kansas	19.8	28.8	5.9	3.2	11.6	69.3
Kentucky	46.8	35.0	14.3	39.5	27.1	162.7
Louisiana	68.5	40.6	28.2	17.7	.1	155.1
Maine	25.4	100.5	15.0	35.4	25.0	201.3
Maryland	201.5	204.0	214.6	15.7	36.6	672.4
Massachusetts	206.5	190.8	149.9	80.0	--	627.2
Michigan	331.8	523.2	307.3	100.4	130.0	1,392.7
Minnesota	142.3	112.1	41.5	30.8	12.9	339.6
Mississippi	32.5	17.4	7.4	14.5	18.2	90.0
Missouri	9.2	160.0	71.9	38.1	27.4	306.6
Montana	13.7	2.7	7.8	--	3.0	27.2
Nebraska	1.8	28.7	23.5	24.1	15.7	93.8
Nevada	.4	30.7	10.8	1.3	--	43.2
New Hampshire	21.3	36.9	62.8	58.5	10.5	190.0
New Jersey	461.9	554.4	105.6	299.6	6.3	1,427.8
New Mexico	17.8	12.8	.1	--	--	30.7
New York	1,047.1	422.4	140.8	102.0	167.2	1,879.5
North Carolina	36.6	66.5	31.3	18.2	1.1	153.7
North Dakota	1.4	3.7	1.7	--	.3	7.1
Ohio	277.2	250.3	313.3	62.7	156.8	1,060.3
Oklahoma	14.4	24.2	28.5	8.1	39.8	115.0
Oregon	41.5	72.3	9.9	13.0	12.6	149.3
Pennsylvania	187.2	343.3	259.0	105.8	1.2	896.5
Rhode Island	9.9	35.6	25.7	--	--	71.2
South Carolina	31.2	29.5	33.3	18.8	17.8	130.6
South Dakota	9.3	1.7	2.8	3.3	.9	18.0
Tennessee	120.6	31.0	17.4	11.9	7.8	188.7
Texas	127.5	165.5	110.3	34.4	11.5	449.2
Utah	14.5	3.5	2.5	1.4	5.5	27.4
Vermont	5.3	13.5	13.5	6.3	3.7	42.3
Virginia	100.0	243.3	81.1	11.0	61.5	496.9
Washington	38.1	67.8	23.8	52.6	5.8	188.1
West Virginia	38.2	32.5	2.1	23.0	--	95.8
Wisconsin	135.1	97.2	21.3	6.6	3.9	264.1
Wyoming	1.5	2.4	--	--	--	3.9
Guam	2.2	10.5	--	4.1	.7	17.5
Puerto Rico	4.2	48.6	76.0	.8	.5	130.1
Virgin Islands	8.0	2.5	2.5	3.1	3.8	19.9

[1]Separate costs for FY 1973 and FY 1974 estimated from FY 1972/1974 total.

TABLE 4

FIVE-YEAR "BACKLOG" CAPITAL ELIMINATION SCHEDULE

(Millions of 1971 Dollars)

Year	"Backlog" at Year End	Growth	Recapitalization	Investment[1]
1971	5081.0			
1972	3871.2	691.7	588.4	2870.9
1973	2740.9	768.1	682.2	2870.9
1974	1706.1	853.0	777.6	2870.9
1975	784.9	947.2	874.6	2870.9
1976	0.0	1051.8	972.9	2870.9
	Total Investment, 1972-1976		14,354.5	
	"Backlog"		6,147.0	
	Growth		4,311.8	
	Recapitalization		3,895.7	

[1]Includes 7.5 percent cost increase factor for each year.

TABLE 5

MODEL INVESTMENT SCHEDULE
INVESTMENT NEEDED TO REDUCE BACKLOG
BY 1976

(Millions of 1971 Dollars)

TOTALS	14,354.5
Alabama	201.0
Alaska	28.7
Arizona	86.1
Arkansas	100.5
California	1,550.3
Colorado	258.4
Connecticut	71.8
Delaware	14.4
Dist.of Columbia	215.3
Florida	502.4
Georgia	387.6
Hawaii	43.1
Idaho	86.1
Illinois	488.1
Indiana	617.2
Iowa	172.3
Kansas	215.3
Kentucky	143.5
Louisiana	129.2
Maine	43.1
Maryland	272.7
Massachusetts	143.5
Michigan	760.8
Minnesota	373.2
Mississippi	114.8
Missouri	258.4
Montana	57.4
Nebraska	100.5
Nevada	43.1
New Hampshire	28.7
New Jersey	229.7
New Mexico	86.1
New York	1,004.8
North Carolina	258.4
North Dakota	57.4
Ohio	890.0
Oklahoma	186.6
Oregon	186.6
Pennsylvania	631.6
Rhode Island	43.1
South Carolina	143.5
South Dakota	28.7
Tennessee	244.0
Texas	1,205.8
Utah	129.2
Vermont	28.7
Virginia	330.1
Washington	315.8
West Virginia	114.8
Wisconsin	502.4
Wyoming	28.7
Guam	
Puerto Rico	201.0
Virgin Islands	

As well as differing from the model estimate, the 1971 survey estimate differs from the 1970 survey estimate of $12.6 billion. Among the reasons for this variance are:

- a different time period for each survey,
- a 15 percent inflation rate in the cost of construction in the period between the two surveys,
- a tightening of water quality standards or implementation schedules in certain situations,
- more comprehensive assessing and reporting.

The evaluation model results in an estimate of $14.3 billion needed to be invested during the period FY 1972-1976 in order to overcome deficiencies in present facilities and to keep pace with growth, capital replacement, and inflation. On the other hand, the survey result of $18.1 billion is an aggregation of State and local estimates of their construction activity during this same period. There are several basic methodological differences between the survey and the model:

1. The model uses statistically derived cost functions, whereas the survey relies on community-generated cost data.

2. The model uses statistically estimated growth and replacement factors and calculates the construction required to maintain the capital stock of treatment plants and to provide for additional population and industrial wastes.

3. The model also includes a specific factor which adjusts for price increases in construction activities. As noted in the survey discussion, State and local intentions are expressed in 1971 dollars.

A primary purpose of the survey is to give an indication of each local government's construction plans in the municipal waste treatment sector. The survey reflects the summation of local activities which, when viewed in the aggregate, presents an estimate of desired construction activity which may or may not commence during the period FY 1972-1976, e.g. compressing of the twenty-year California program into five years. The purpose of the model is slightly different in that it provides an estimate of the investment activity between 1972 and 1976 that local governments will be required to undertake in order to maintain their current growth and replacement needs and make progress toward constructing those facilities required to meet water quality standards.

Municipal Accomplishments

In evaluating the progress being made in the nation's water pollution abatement effort, it is important to report trends and current levels in waste production and treatment. The report presents accomplishment data for the years 1968-1972. The emphasis of this report will be upon the municipal sector since this is the area in which the greatest amount

of federal activity has been concentrated over the past years.

The data for 1968-1970 was obtained from the General Discharge File maintained by the Office of Water Programs. The records for 1971 and 1972 are based partially on data from the file and projections based on a trend analysis of existing data. The results of this analysis are included in Table 6. The table presents accomplishments in terms of population sewered and increases in wastes treated. The table also indicates the level of treatment and the decrease in population receiving primary treatment. The percentage of population receiving advanced treatment has not significantly increased.

The discussion of program accomplishments will be more extensively analyzed in the next year's cost study. The extent to which the projected expenditures through 1976 will effect these accomplishment measures will be analyzed and presented along with action accomplishments for the period.

Trends

Ambient

EPA is developing an indexing procedure to evaluate water pollution. The water pollution index allows any water body or set of water bodies to be described with respect to prevalence, duration, and intensity of water pollution. This index has as a basis data which measures deviations from established standards of water quality.

In 1970 an assessment of the prevalance of pollution was first made. It indicated that 27 percent of America's stream miles were polluted. Measuring the prevalence of pollution alone, the assessment in 1971 states that 29 percent of the nation's waters were polluted during the year. In point of fact, the assessed prevalence of water pollution in 1971 may understate the amount of the increase, but there are also differences in the method and data used in calculating the estimated prevalence of pollution.

Every part of the nation has some water pollution, but the shares are very unevenly distributed. In 1971, there were almost twice as many polluted stream miles, in a relative sense, east of the Mississippi River as west of it (cf. Table 7).

The 1971 pollution index takes into account the duration and intensity of pollution as well as the prevalence. The relative water pollution standing of federal administrative regions is not significantly changed when the frame of reference shifts from simple prevalence of pollution to an index of prevalence weighted by relative duration and severity.

The distributional features become more apparent when the categorical focus is shifted from political to natural boundaries. The nine areas

TABLE 6

PROGRAM ACCOMPLISHMENTS

	1968	1969	1970	1971[1]	1972[1]
Sewered Population (millions, persons)	140	144	148	152	156
Waste Strength gross wastes treated by municipal plants (million/pounds/year BOD's)	14,137	14,773	15,438	16,133	16,859
Level of Treatment (Percent)					
Sewered Population Untreated	7	7	6	6	5
Sewered Population Primary	31	30	28	25	24
Sewered Population Secondary	62	63	66	68	70
Sewered Population Advanced	<1	<1	<1	<1	<2

[1]Based upon Historical Growth Trends 1962-1970.

TABLE 7

RELATIVE INCIDENCE OF WATER POLLUTION

EPA Region	Percent Of Stream Miles Polluted	Duration Intensity Factor	Duration-Intensity As a Percent of U.S. Mean	Percent Polluted U.S. Miles
I Boston	16.4	.62	151	6.4
II New York	42.4	.45	110	2.7
III Philadelphia	34.7	.58	141	11.7
IV Atlanta	37.9	.45	110	19.4
V Chicago	64.5	.43	105	24.3
VI Dallas	21.5	.37	90	13.1
VII Kansas City	12.5	.33	81	3.1
VIII Denver	25.0	.23	56	7.4
IX San Francisco	23.5	.20	49	5.2
X Seattle	19.4	.11	27	7.2
Contiguous U. S.	29.3	.41	100	100.0
East of Mississippi River	38.5	.48	117	63.9
West of Mississippi River	20.6	.28	68	36.1

chosen are shown in Figure 1. The degree to which water pollution is concentrated now becomes evident. Three areas (Ohio, Southeast, and Great Lakes) contain 23.9 percent of the nation's stream miles, but 48.9 percent of the polluted stream miles (cf. Table 8). Extensive pollution is very nearly limited to the Ohio, Great Lakes, and Southeastern drainage systems, and though the Northeastern watersheds are in a class with the other three, with respect to duration and intensity of pollution, they tend to dominate that measure as well.

On the basis of the available data, of the four apparently significant shifts in reported pollution that took place (cf. Table 8)--in the Ohio, Gulf, Missouri, and Northeastern Basins--three are so obscured by variations in procedure that it is difficult to evaluate the degree of real change. Both the Gulf and the Missouri Basins reported an enormous improvement in compliance with water quality standards. But in each case, the 1970 assessment failed to make allowance for legally sanctioned breaches of water quality criteria that resulted from precipitation; and in both cases, that exception is significant. In the case of the Ohio River Basin, the 1970 assessment concentrated on the quality of major waterbodies, overlooking smaller tributaries. But in Ohio many streams are polluted at the source as a result of acid drainage of mountain coal mines. Failure to account for this total prevalence of pollution in 1970 is at least partly responsible for the increase in reported pollution in 1971. Thus the conclusion is that substantially the same number of river miles were polluted in 1971 as in 1970.

It should be noted, however, that the line of water pollution does seem to be holding in the face of rising population and industrial production. Also, while national statistics do not indicate a marked change in water quality, some individual waterbodies have been notably improved, e.g. Lake Washington.

In coming years, as comparable data is developed, the water pollution index will be able to better identify trends in water pollution for the nation.

Manufacturing

Trends in the manufacturing use of water are varied. A number of economic and institutional changes in the last decade lead to the expectation that incentives have been provided for industry to curtail and treat liquid-borne wastes. In 1966, the States were required by law to set standards for interstate waterways. This led to an increase in water pollution control activity. Laws have also increased federal share and funding levels of grants for municipal treatment works' construction, which represents an increase in subsidies to connected industrial firms. Pressure on existing supplies of freshwater provide an incentive to economize on water intake, which in turn produces process changes, including recycling. Offsetting these incentives, however, are growth of production and consequent residuals production. Over the period 1959-1968, the Federal Reserve Board Index of Industrial Production for Manufacturing increased 59 percent.

FIGURE I

RELATIVE WATER POLLUTION

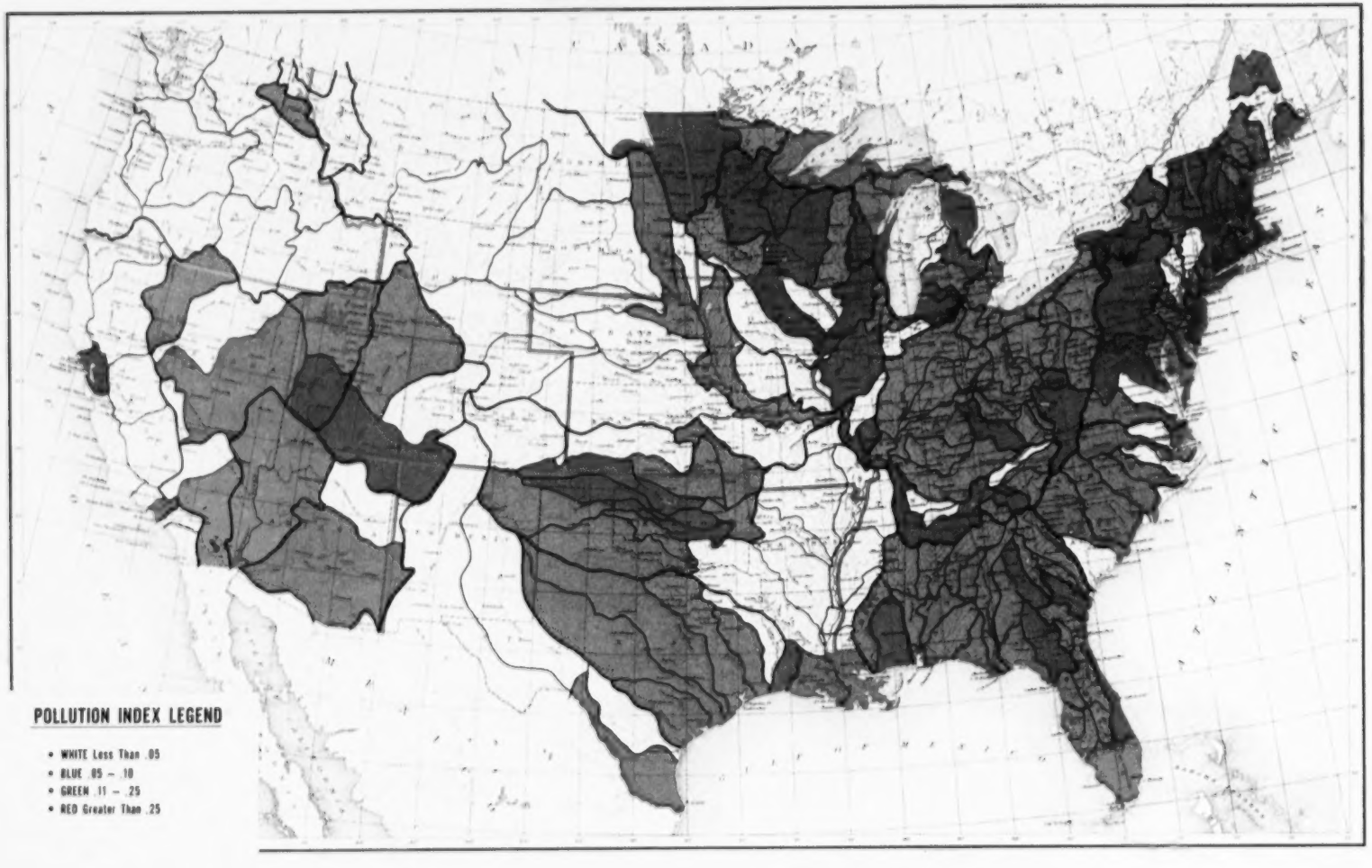

TABLE 8

WATER POLLUTION INDEX SUMMARIZED FOR MAJOR DRAINAGE AREAS, 1970 AND 1971

Major Watershed	Stream Miles	Polluted Miles			1971 D.I. Factor
		1970	1971	Change	
Ohio	28,992	9,869	24,031	+13,746	.42
Southeast	11,726	3,109	4,490	+ 1,381	.74
Great Lakes	21,374	6,580	8,771	+ 2,191	.45
Northeast	32,431	11,895	5,823	- 6,072	.61
Middle Atlantic	31,914	4,620	5,627	+ 869	.47
California	28,277	5,359	8,429	+ 2,499	.27
Gulf	64,719	16,605	11,604	- 5,001	.35
Missouri	10,448	4,259	1,839	- 2,420	.31
Columbia	30,443	7,443	5,685	- 1,758	.12
U. S.	260,324	69,739	76,299	+ 5,435	.41
U. S. Less Ohio	231,332	59,870	52,268	- 8,311	.40
U. S. Less Columbia	229,881	62,296	70,614	+ 7,193	.43

Industrial water intake and discharge is increasing at a less pronounced rate than industrial output. The proportion of industrial wastewater discharge that is treated continues to grow, and amounted to 37 percent of discharge in 1968. Waste treatment growth was less between 1964 and 1968 (3.1 percent annual rate of increase), however, than between 1959 and 1964 (10.5 percent annual rate of increase). Most of the increase in industrial waste treatment occurred at the factory. For, although use of public sewers and waste treatment plants is the main method of waste disposal for a number of manufacturing sectors, the portion of industrial effluent discharged to public facilities dropped from almost 9 percent in 1959 to a little more than 7 percent in 1968.

Discharge of industrial wastewater to public sewers places the requirement for adequate waste treatment upon local public agencies responsible for municipal waste treatment. As wastewater treatment at the secondary level (i.e., about 80 to 90 percent BOD reduction) or above becomes more prevalent among municipalities, the degree of treatment of sewered industrial wastewater should generally increase. However, as municipalities raise their target rates of waste removal, they must become more discriminating about the types and timing of industrial discharges that they will accept in order to prevent adverse consequences on the operation of their treatment works. For the sewered manufacturing plant, greater selectivity can translate into separation of waste streams and/or treatment of discharges bound for the sewer, both of which entail an increase in costs. All of the decline of industrial wastewater to sewers took place in the 1959-1964 period. Over the 1964-1968 span relative discharge to sewers remained virtually constant, with the absolute amount of sewered discharge increasing slightly. Although the relative amount of industrial discharge going to sewers is rather small, municipal waste treatment is the primary method of curtailing industrial liquid-borne pollutants from the food processing, textiles, rubber, leather, and the various metal manufacturing industries.

Four broad methods of curtailing the polluting effects of industrial liquid-borne wastes can be distinguished: (1) Waste treatment facilities can be added prior to discharge; (2) A plant can discharge its wastes to a sewer; (3) Application to land, either through surface irrigation or well injection, can be a very thorough treatment technique, provided that precautions to prevent ground water contamination or runoff of pollutants are exercised; (4) Process change is, from both an environmental and administrative standpoint, perhaps the most attractive technique because of its reliability, predictability, and potential for recycling of waste materials.

One piece of evidence suggests that firms are directing investments toward process change in order to reduce waste loadings. The survey on water pollution abatement costs conducted by the Conference Board indicates that 27.9 percent of capital expenditures for water pollution control by the sampled plants were for manufacturing changes to reduce water pollution. This percentage varied from 35.6 percent in paper and allied products to 2.8 percent in textile mill products. However, lack of data

prevents an analysis and evaluation of the extent and changes over time in alterations of production process that reduce the amount of residuals generated.

The real price of water--measured by its scarcity and the cost of its application--is increasing for industry. In consequence, manufacturers are using it with growing intensity. Economizing on water intake, and thus discharge, is often accompanied by increased attention to the production and handling of water-borne residuals, and materials control generally, which tend to decrease the amount of pollutants discharged. Recycling and reuse of water is a common method of economizing on water intake per unit of product. Recycling of water can cause an increase in the concentration of pollutants in industrial wastewater which generally lowers the cost of treatment per unit of waste and cheapens the cost of by-product recovery. The trends in industrial water use indicate that water intake increased over time for all regions and for most industries. This finding is not surprising, given the growth in production in the economy over the period 1959-1968. However, growth in production alone hardly accounts for differences in the trends in water intake across regions and across industries; the percentages of variation in water intake growth explained by growth in value added are only 18 and 21 percent for regions and for industries, respectively, neither of which is different from zero by the usual tests of statistical significance. In other words, growth in water withdrawals by industry has not been primarily conditioned by growth in industrial production.

Use of capital to provide more effective utilization of each intake unit at each application and to increase the number of applications by recycling is indicated by positive correlations between growth of output per intake gallon with (a) growth of output, and (b) water scarcity. Neither characteristic correlates with growth of industrial waste treatment, suggesting that management response to an increase in the price of water is limited to each firm's internal operations and does not extend to measures that will reduce prices for society as a whole. Nevertheless, increased demand for water leads to processing methods that result in reduced dependence on the available supply, thus supplementing--and in some degree substituting for--the effect of waste treatment. Economic behavior, then, leads to process changes which can be expected to decrease industrial waste loadings. At first appearance it might seem paradoxical that increased industrial production and increased pressures on available supplies of fresh water, both of which are pointed to as prime causes of environmental deterioration, also lead to industrial process changes that have--at least relative--environmentally beneficial effects. The paradox is easily resolved by viewing industrial intake and discharge of water as activities subject to the same set of rational calculations that govern the use of any productive input.

Construction Industry--Municipal

The question of the ability of the construction industry for municipal

wastewater facilities to construct the planned investment activity must be considered in projecting the level of activity in this sector. Under present conditions it takes close to five years, on the average, to complete a municipal sewerage project, while in 1957, when Federal financial assistance for sewage construction was initiated, 55 percent of the value of new starts had been put in place in the same year.

A limiting factor on the supply capability is the phased expansion of the wastewater facilities construction sector. This sector, like many economic sectors, contains numerous institutional constraints which may inhibit the ability to expand to meet the indicated demand. The recent trend in the expansion of construction activity in the municipal wastewater sector is slightly over a 28 percent six-year growth rate.

If the historical trend in new construction activity in this sector maintains this 28 percent annual growth pattern, then the projected activity in the next five years is $18.9 billion. This includes a 15 percent price level change for 1971. However, if the cost increase rate is held down and the trend is more nearly like the years 1965 to 1970 which had an average price level change of 7.5 percent, then the rate of growth in construction activity would be 25 percent and projected starts would amount to $17.4 billion.

The 1971 survey of municipalities' planned construction activity states that $18.1 billion in 1971 dollars is planned in the next five years. Add to this the value of projects pending construction of $3.4 billion and the survey estimates that total new starts in construction will be $21.5 billion through 1976. Such activity is highly unlikely given the trend in recent construction works. On the other hand, the evaluation model estimate of $14.3 billion plus the $3.4 billion in pending projects adds to $17.7 billion of planned construction activity for the next five years. This estimate assumes 7.5 percent average cost increase during that period and compares favorably with the historical trend assuming a 25 percent growth rate.

Construction Industry--Industrial

The most likely water pollution abatement investment schedule must be one that eliminates deficiencies at a fairly even rate, while the processes of growth and replacement assert their effects as functions of the capital structure and the rate of economic activity. Such a schedule, assuming the probable set of costs associated with median hydraulic efficiency and a rate and distribution of output growth for the period 1968-1976 similar to that of 1959 to 1968, dictates the investment of $11.0 billion ($8.1 billion in 1967 dollars) between 1968 and 1976 for treatment of manufacturers' wastes (cf. Table 9).

There is no question that the indicated schedule will be difficult to achieve. Manufacturers are responding to waste treatment requirements at the same time that the public sector is increasing its capitalization

TABLE 9

ANNUAL EXPENDITURES CONSISTENT WITH
STANDARDS COMPLIANCE BY 1976
(PROBABLE COST: MEDIAN EFFICIENCY)

SIC	INDUSTRY	CAPITAL EXPENDITURE,[1] MILLION OF 1967 DOLLARS										
		1968	1969	1970	1971	1972	1973	1974	1975	1976	TOTAL	Capital Required, 1976
20	Food and Kindred Products	93.8	114.7	125.5	131.4	137.4	143.4	149.5	155.6	161.9	1213.2	1102.3
22	Textiles	24.1	31.9	35.4	37.6	39.8	42.1	44.6	47.1	49.7	352.3	317.1
24	Lumber & Wood Products	12.4	12.4	13.3	13.7	14.2	14.6	15.1	15.5	16.0	127.2	98.9
26	Paper & Allied Products	118.8	134.4	146.2	152.5	158.9	165.3	171.8	178.4	185.1	1411.4	1380.9
28	Chemical & Allied Products	65.0	110.3	123.6	134.2	146.2	160.0	176.1	195.0	217.2	1327.6	1439.9
29	Petroleum & Coal	72.6	79.2	85.2	88.3	91.3	94.1	97.4	100.4	103.5	812.3	872.3
30	Rubber & Plastics	9.5	13.5	15.0	15.9	16.8	17.7	18.6	19.6	20.6	147.2	121.3
31	Leather	9.0	11.1	12.1	12.7	13.2	13.8	14.3	14.9	15.5	116.6	104.9
32	Stone, Clay & Glass	17.1	19.9	21.9	23.0	24.0	25.1	26.2	27.3	28.5	213.0	183.5
33	Primary Metals	112.7	162.9	182.0	194.6	208.2	222.9	238.8	256.2	275.3	1853.6	1649.3
34	Fabricated Metal Products	11.2	16.2	18.0	19.0	20.1	21.2	22.4	23.5	24.7	176.3	147.4
35	Machinery	8.4	9.1	9.9	10.3	10.7	11.1	11.5	11.9	12.3	95.2	85.9
36	Electrical Equipment	11.7	15.4	16.9	17.8	18.6	19.5	20.3	21.2	22.1	163.5	147.4
37	Transportation Equipment	8.2	9.6	10.5	10.9	11.4	11.8	12.3	12.8	13.2	100.7	92.3
	Manufacturing	574.5	740.6	815.5	861.9	910.8	962.6	1018.9	1079.4	1145.3	8110.1	7743.4
	For Comparison: Reported Investment	416	579	723	828							

[1] Net investment (difference between median requirement and industry-supplied capital at 1968) plus annual growth and replacement.

of waste treatment works as explained above.

In spite of increasing evidence in the form of delayed deliveries, lengthening construction times, and soaring construction costs, the ability of the sewerage construction industry to supply a ballooning demand has never been investigated, and scarcely questioned. There is reason to believe, however, that the supply of suitable construction services will prove far more critical to meeting waste discharge standards by 1976 than will financial commitment. EPA is conducting a study of the construction industry's supply capabilities to meet the anticipated demand.

It should be noted that secular expansion of the level of investment is necessary, even with a constant increment abatement strategy. Growth and replacement demands account for over half of the indicated capital requirement to 1976, and their level is in large measure determined by the dimensions of the capital base. The schedule illustrated in Table 9 may be slightly over-ambitious in that it embodies rates of output growth that applied in one of the most expansionary periods in our history. A slower rate of economic growth would, of course, permit attainment of the target with a lower rate of increase than the 8.9 percent per year dictated by the projection. But internal growth of the system--that is, installation of the treatment capital associated with 1968 output levels--is a more significant influence on the indicated annual level of investment than the treatment requirements that arise out of projected production growth.

Evaluation of Benefits and Costs[1]

Aside from the specific municipal and industrial sectors, attention to the marginal benefits and costs of various treatment levels from a national point of view is necessary to insure that the water pollution goals sought are defensible in terms of their net benefit to society. An analysis of the marginal costs and benefits to levels of treatment suggests:

1. Because costs accelerate rapidly as higher levels of treatment are achieved (cf. Figure 2 and Table 10) the total cost of meeting very high levels of treatment approaching zero discharge could be many times those required to meet current water quality standards.

2. The improvement in beneficial uses of water from a no discharge policy is likely to be modest compared to the costs. The ultimate goal of any pollution control program is to achieve certain environmental quality objectives. These goals have traditionally

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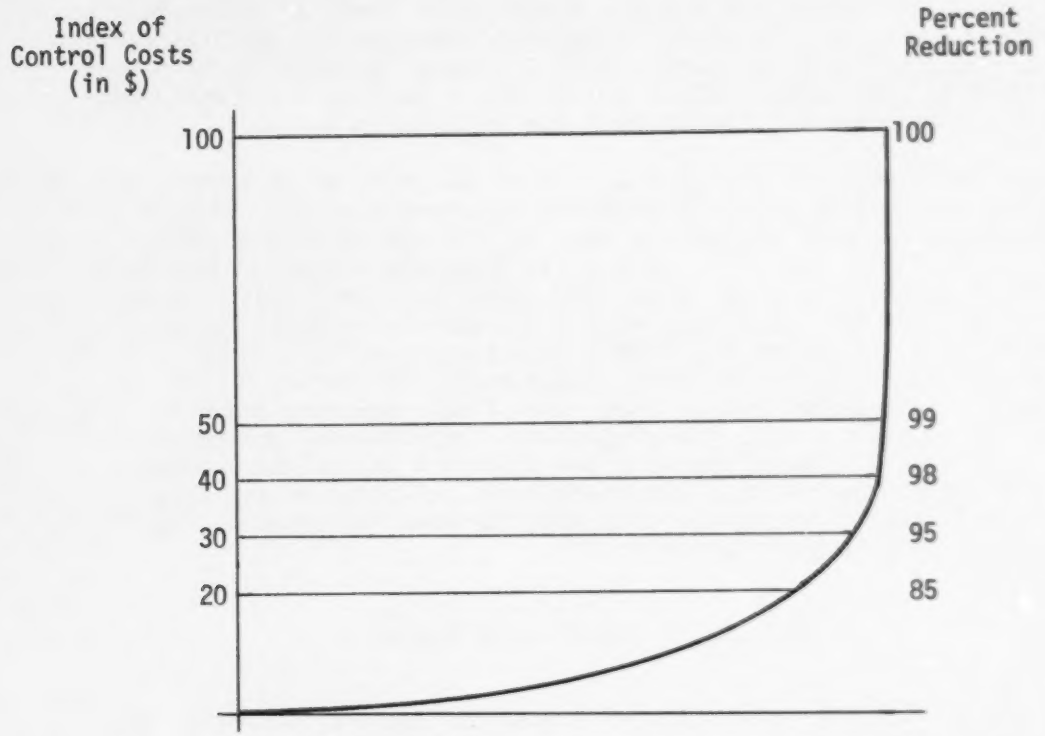
[1] A summary of "Environmental and Economic Benefits and Costs Related to Various Water Pollution Abatement Strategies", paper prepared by EPA and CEQ.

FIGURE 2

TOTAL CONTROL COSTS AS A FUNCTION OF EFFLUENT CONTROL LEVELS



Source: Interior 1965 Saline Water Conversion Study
Young and Pisano: "Nonlinear Programming Applied to Regional Water Resource Planning".

FWPCA: Cost of Clean Water, 1968, Volume I.

FWQA: Cost of Clean Water, 1970, Volume IV.

TABLE 10

INDEX OF POLLUTION CONTROL INVESTMENT COSTS
RELATED TO LEVEL OF ABATEMENT

Level of Removal (Percent)	Increased Percent of Removal	Cost Index	Cost Per Increased Percent of Removal
100	1	500	250
99	1	250	50
98	3	200	17
95	10	150	5
85	--	100	--

been set forth in standards of quality that deal with preventing adverse effects or achieving certain beneficial uses. For example, higher water quality provides such beneficial uses as water supply, recreation, and fish and wildlife. The least costly method of meeting these objectives is to tailor effluent reductions to meet those ambient objectives. To the extent that the effluent reductions are more stringent than those which are required, excessive costs are incurred needlessly. This is particularly true at high control levels where control costs escalate very rapidly. A study of cost and benefits in the Delaware Estuary performed by the Federal Water Pollution Control Administration illustrates the relationship of benefits to costs in the following table:

Dissolved Oxygen (mg/l)[1]	Index of Costs of Control	Index of Recreational Benefits
6.5	575	128
5.5	320	115
5.0	150	105
4.0	100	100

[1]Approximate values, although this factor and others varied by areas within the estuary.

The Delaware study is now nearly a decade old. EPA recognizes the paucity of information concerning economic measures of benefits and is making a concerted effort to refine costs and develop methodologies for quantifying benefits.

3. A number of adverse environmental impacts would occur such as higher energy consumption and solid waste problems. Disposal on land will increase dramatically, resulting in potential soil and water contamination. High effluent limitations would also encourage deep-well disposal with great potential for long-term damage to underground water supplies.

4. Large resources devoted to achieving small increases in water quality benefits have the effect of withdrawing resources from other environmental efforts or other national priorities.

SUMMARY OF METHODOLOGIES AND MODELS USED IN ANALYSIS

PDI Index

The basic element of the index is a simple measurement or judgement. Once standards have been determined for a set of water quality parameters, the procedure calls for a comparison of those standards with measured quality. Where any variable or combination of variables does not meet or exceed the standard, then a state of pollution exists--by definition.

This rather rudimentary test was first applied in 1970, when a ratio of polluted waters to total waters was established for the nation, using the simple formula:

$$\frac{P}{M} = \text{prevalence of pollution}$$

Where P = number of stream and shoreline miles in which one or more of the established chemical and biological criteria had not been met one or more times,

M = total stream and shoreline miles, to and including third-order tributaries.

An assessment of pollution in terms of mere prevalence is essentially unsatisfactory. Degree of pollution and its persistence are significant dimensions of the phenomenon--perhaps the more significant, given the range of uncertainties that attach to the water quality criteria. The water pollution index takes these factors into account by establishing separate weighting values to a circumstance of pollution, according to its seasonal characteristics and its interference with uses sanctioned by the water quality standards. The simple formula for determining the prevalence of pollution becomes only slightly more complex, but the level of effort and judgement required to apply the formula is increased enormously when it becomes:

$$\frac{P \cdot D \cdot I}{M} = \text{Water Pollution Index}^2$$

Where D = a factor ranging from 0.4 to 1.0 to express the inter-seasonal duration of pollution,

I = a factor ranging from 0.1 to 1.0 to express the intensity of water pollution in terms of damage.

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[2]An explanation of these variables is contained in the Technical Appendix (Volume II of this report).

When reach-by-reach pollution conditions are weighted to give expression to duration and intensity, an index is formed which provides a consistent measurement of unequal variables against a common base--in this case, the water quality standards.

Industrial Model

The data and interpretations of the industrial sector of this report are based largely upon a modelled restructuring of Water Use in Manufacturing. This portion of the Census of Manufacturers, 1967 provides a data catalog on the water use characteristics of 9402 manufacturing establishments that reported the intake of 20 million gallons or more of water in 1967.

The 9402 establishments that were reported upon in Water Use in Manufacturing are too small a number to adequately reflect manufacturers' costs. The Census of Manufacturers, 1967 does not provide any indication of total manufacturers' use of water. However, Water Use in Manufacturing, 1963 did present such data. The sample of 9402 establishments was then, expanded on the basis of the 1963 census to include over 14,000 establishments, that being the greater part of those reported to have an intake of 10 million gallons or more in 1964 (cf. Table 11).

The premise that waste characteristics have a significant relationship to waste treatment costs leads to a regrouping of the industrial categories reported in Water Use in Manufacturing, 1967. They were grouped according to the kinds and concentrations of waste products that were considered to be characteristics of various industrial processes on the basis of an extensive literature search.

Having established a study population, it was necessary to define the population in terms of size distribution and locational characteristics. The census data do not include such information, so they were disaggregated on the premise that the largest water-using establishments in each of the 320 SIC categories are identical with the largest users of labor in each category. Since employment data is as protected by federal sources as water use data, Dun and Bradstreet files were used to establish distributional characteristics.

With location and size distributions of the model components approximated on the basis of the employment surrogate, employment data were translated into hydraulic terms with the use of annual water intake per employee factors derived from Water Use in Manufacturing, 1967.

To accommodate locational factors, a multiplier was applied to the intake per employee factor, representing the ratio of intake per employee in each water use region to national water use per employee. Annual wasteflow and wastewater requiring treatment were constructed from these factors (cf. Table 12).

TABLE 11

COMPARISON OF CENSUS
REPORTED ESTABLISHMENT AND
WATER DATA FOR
FACTORIES WITH INTAKE ≥ 20,000,000G/YR.
WITH MODELLED FACTORIES

SIC	Industry	Percent of Reported Intake	Percent of Calculated Treatable Discharge	Establishments Reported	Establishments Modelled	Difference
20	Food & Kindred Products	5.2	8.3	2345	4494	+91%
22	Textiles	0.9	2.1	684	1021	+49%
24	Lumber & Wood Products	0.8	1.9	188	405	+116%
26	Paper & Allied Products	14.6	29.5	619	862	+39%
28	Chemical & Allied	29.0	27.8	1125	1421	+21%
30	Rubber & Plastics	0.9	0.6	301	459	+52%
31	Leather	0.1	0.5	92	215	+134%
32	Stone, Clay, Glass	1.6	2.3	586	945	+61%
33	Primary Metals	32.6	17.8	841	1137	+35%
34	Fabricated Metals	0.4	1.1	569	1037	+82%
35	Machinery	1.2	1.0	471	790	+68%
36	Electrical Equipment	0.8	1.4	562	817	+45%
37	Transportation Equipment	2.0	1.6	392	562	+44%
	Manufacturing	100.0	100.0	9402	14,499	+54%

TABLE 12

BASIC ELEMENTS OF THE INDUSTRIAL WASTE TREATMENT MODEL

INDUSTRIAL CLASSIFICATION		NUMBER OF ESTABLISHMENTS		PERCENT OF PROCESS WASTEWATER REQUIRING TREATMENT												
CODE	NAME	10-19 MGY	≥ 20 MGY	:1:	:2:	:3:	:4:	:5:	:6:	:7:	:8:	:9:	:10:	:11:	:12:	:13:	:14:	:15:
201	MEAT PRODUCTS	189	541	250.	2.00	1.2		33			80			166	33			
202	DAIRY PRODUCTS	456	729	250.	1.00	1.2			50					100				
203	CANNED, FROZEN PRESERVED FOODS	174	518	200.	2.00	1.2		50				100		140				
2041-6	FLOUR AND OTHER GRAIN MILL PRODUCTS	60	78	250.	1.00	1.2						100		100				
2046	WET CORN MILLING	4	17	200.	3.00	1.3		100				100		100				
205	BAKERY PRODUCTS	153	208	250.	1.00	1.2		50				100		100				
2061-2	CANE SUGAR	6	67	150.	3.00	1.35		100		100		200		100				
2063	BEET SUGAR		69	150.	3.00	1.35		100		100		200		100				
207	CONFECTIONARY AND RELATED PRODUCTS	153	208	250.	1.00	1.2		50				100		100				
208	BEVERAGES	239	412	300.	2.00	1.35		25				100		125				
209	MISCELLANEOUS FOODS AND KINDRED PRODUCTS	220	380	200.	1.00	1.3				50		100		100				
203X	OTHER FOOD PROCESSING			250.	1.00	1.25		35		25		99		90				
2211	WEAVING MILLS, COTTON	51	148	250.	2.00	1.2				20		100		100				
2221	WEAVING MILLS, SYNTHETIC	29	76	250.	2.00	1.3		50	44					66				
2231	WEAVING AND FINISHING MILLS, WOOL	18	82	250.	3.00	1.2				35		100		100				
226	TEXTILE FINISHING, EXCEPT WOOL	25	139	250.	1.00	1.2				20		100		100				
223X	OTHER TEXTILES	176	261	250.	1.00	1.2		13	11	19		64		91				
24	LUMBER AND WOOD PRODUCTS	175	231	250.	2.00	1.2				50		75		100				
261	PULP MILLS	1	36	350.	4.00	1.35				52		43		86				
2621	PAPER MILLS, EXCEPT BUILDING PAPER	6	269	350.	2.00	1.35				40		100		100				
2631	PAPERBOARD MILLS	14	185	350.	2.00	1.35				40		100		100				
264	MISCELLANEOUS CONVERTED PAPER PRODUCTS	59	100	350.	1.00	1.35				60		100						
265	PAPERBOARD CONTAINERS AND BOXES	94	48	250.	1.00	1.2						100		100				
266	BUILDING PAPERS	5	47	350.	2.00	1.3						100		100				
26XX	MISCELLANEOUS PAPER PRODUCTS			350	2.00	1.3				45		90		100				
2812	ALKALIES AND CHLORINE	1	31	350.	1.00	1.35		20	100	60								
2813	INDUSTRIAL GASES	36	82	350.	1.00	1.35		20	100	60								
2815	CYCLIC CRUDES AND INTERMEDIATES	7	64	350.	3.00	1.35	20	25	20	33	67			100				
2816	INORGANIC PIGMENTS	4	27	250.	1.00	1.35		20	100	60								
2818	INDUSTRIAL ORGANIC CHEMICALS	20	147	350.	3.00	1.35	20	25	20	33	67			100				
2819	INDUSTRIAL INORGANIC CHEMICALS	39	198	350.	1.00	1.35		29	100	60								
282	FIBRES, PLASTICS RESINS	31	177	350.	4.00	1.35		50	15	50		100		100				
283	PHARMACEUTICALS	22	75	250.	2.00	1.2		29		80		65		185	60			
284	TOILETRIES AND DETERGENTS	41	64	250.	1.00	1.25				33	100			33				
2851	PAINTS	28	53	250.	1.00	1.25		20	100	60								
2861	WOOD CHEMICALS	4	19	350.	2.00	1.35		25	20	33	67			100				
287	AGRICULTURAL CHEMICALS	28	85	350.	1.00	1.35			20	30	77		70					
289	MISCELLANEOUS CHEMICAL PRODUCTS	32	116	300.	1.00	1.3	10	20	60	45	23			50				
28XX	MISCELLANEOUS CHEMICALS			300.	1.00	1.3	10	20	60	45	23			50				
2911	PETROLEUM REFINING	25	206	350.	2.00	1.35	100	20	40	20								130
29XX	PETROLEUM AND COAL--OTHER THAN REFINING	35	69	300.	1.00	1.3	40	20	40	20	60			100				
30	RUBBER AND PLASTICS	142	317	350.	1.00	1.3		50	15	50		100		100				
3111	LEATHER TANNING AND FINISHING	22	88	250.	4.00	1.2		100	100	100				100				
31XX	LEATHER	77	28	250.	1.00	1.2					100			100				

Explanation of Numbered Columns

:1: Operating Year (Days)
:2: High Waste Concentration Factor
:3: Installation Multiple Factor

Columns 4 thru 15--Treatment Processes

:4: Oil Separation
:5: Equilization
:6: Coagulation and Sedimentation
:7: Neutralization
:8: Flotation
:9: Sedimentation
:10: Aeration
:11: Biological Stabilization
:12: Chlorination
:13: Evaporation
:14: Incineration
:15: Activated Sludge

TABLE 12 (Cont'd.)

BASIC ELEMENTS OF THE INDUSTRIAL WASTE TREATMENT MODEL

INDUSTRIAL CLASSIFICATION		NUMBER OF ESTABLISHMENTS		PERCENT OF PROCESS WASTEWATER REQUIRING TREATMENT														
CODE	NAME	10-19 MGY	≥ 20 MGY	:1:	:2:	:3:	:4:	:5:	:6:	:7:	:8:	:9:	:10:	:11:	:12:	:13:	:14:	:15:
3211-322-3	GLASS	36	148	350.	1.00	1.2			100	100		50						
3241	CEMENT	10	140	350.	1.00	1.2			100	100								
325-326	CLAY	73	51	300.	1.00	1.2			100	100								
327	CONCRETE AND PLASTER	102	179	300.	1.00	1.25			100	100								
3281	STONE	10	28	250	1.00	1.25			100	100								
329	NON-METALLIC MINERALS	49	121	250	1.00	1.2			100	100								
32XX	MISCELLANEOUS--STONE, CLAY, GLASS			250	1.00	1.2			100	100								
3312	BLAST FURNACES AND STEEL MILLS	13	189	350	1.00	1.35	75	75	100	75				35				
331X	STEEL ROLLING AND FINISHING	35	107	350	1.00	1.3	75	50	100	75								
3321	GRAY IRON FOUNDRIES	41	76	300	1.00	1.2		50		50		100						
332X	IRON AND STEEL FOUNDRIES	13	189	300	1.00	1.2		50		50		100						
3331	PRIMARY COPPER	1	26	350	1.00	1.3		100	100	100								
3332-3	PRIMARY LEAD AND ZINC	1	22	350	1.00	1.3			100	100								
3334	PRIMARY ALUMINUM		21	350	1.00	1.3			60	60						40		
33XX	OTHER PRIMARY METALS	149	254	300	1.00	1.3		45	70	75		30						
34	FABRICATED METALS	404	633	250	1.00	1.25		56	93	110					22			
35	MACHINERY	281	510	250	1.00	1.25		56	93	110					22			
36	ELECTRIC MACHINERY	255	562	250	1.00	1.25		56	93	110					22			
37	TRANSPORTATION EQUIPMENT	115	447	250	1.00	1.25		56	93	110					22			
39	MISCELLANEOUS MANUFACTURING*	99	117	250	1.00	1.25		25	40	55		47	12	62	5			

Explanation of Numbered Columns

:1: Operating Year (Days)
:2: High Waste Concentration Factor
:3: Installation Multiple Factor

Columns 4 thru 15--Treatment Processes

:4: Oil Separation
:5: Equilization
:6: Coagulation and Sedimentation
:7: Neutralization
:8: Flotation
:9: Sedimentation
:10: Aeration
:11: Biological Stabilization
:12: Chlorination
:13: Evaporation
:14: Incineration
:15: Activated Sludge

*Arithmetic mean for all listed industries.

The values for daily wasteflow requiring treatment were then multiplied by factors intended to give effect to: (a) proportion of treatable wastewater requiring a given method of treatment; (b) costs based on flow to cost relationships for construction and operation of the given normal waste strength; and (c) a factor intended to provide an approximation of non-recurring installation costs imposed by land purchase, repiping, and production losses. The sums of individual factory components are available in a number of fashions for reporting purposes, being retrievable according to SIC grouping (one to four digit), location (county, State, water use region, nation), or waste treatment process. Substitution of alternative flow, treatment, and cost variables allows assessment of impact of policy or technological changes at any level from a single factory to all manufacturing.

Water Use in Manufacturing, 1967 also provided the information upon which current capitalization estimates were based. The document reports of plants and volume of flow in a variety of treatment categories for industrial sectors. On the basis of previously established operating rates and the same set of cost functions used to determine requirements, existing facilities were evaluated in terms of average daily flows through facilities of specified types.

It should be noted that--quite apart from distortions involved in assessments at the mean--the procedure significantly understates the degree of required capital that is currently available in many industries. In addition to facilities operated by plants using less than 20 million gallons, wastes discharged to public sewers and treated by public sewage treatment facilities are not accounted for; and in a number of cases, governmental bodies, through the normal sewage handling systems, accepted a major part of an industry's discharge. Nor can wastes discharged to land (septic tanks, irrigation, deep well disposal) be accounted for in financial terms. In either case, the Bureau of Census simply does not provide sufficient information to permit an evaluation.

The method of calculation was dependent on the treatment of all process waste streams for each pollutant identified with the process by the most effective (as opposed to most efficient) conventional treatment method now available. And wherever options might be discerned, the higher (or highest) cost solution to the problem was assumed. Consonant with a procedural requirement that all wastes be treated to the highest degree possible with conventional technology, it was assumed that all waste constituents, except dissolved mineral solids, would be removed reduced, or emended. In effect, it was assumed that floating and settleable materials be removed--with chemical assistance in many cases--that dissolved organics be stablized, that caustics and acids be neutralized, that potential pathogens be subject to disinfection, that uneven waste streams be equalized, and even--in some particularly difficult situations--that concentrated waste streams be evaporated or incinerated.

Municipal Model

This model is a mathematical simulation of investment in public waste handling systems. The model calculates the value of recognized improvements needed in the treatment or operation of waste treatment systems as stated in the (1971) Municipal Waste Inventory. It correlates a series of equations that define size to cost relationships for basic waste-handling procedures and equipment.

The model calculates the average cost of installing or constructing the particular facilities--sized according to a normal statistical distribution of capacity to indicated load for existing plants in the same State. The costs are stated in terms of constant dollars. (Sewer and Sewage Treatment Plant construction Cost indices, supplied by EPA, may be applied to modify price levels.) This procedure supplied the value of recognized improvements needed in waste treatment or operation of waste treatment systems.

The second part of this modeling technique is a calculation of the current replacement value of facilities in place. The current replacement value was calculated on the basis of costs experienced in building facilities with similar design flow and removal efficiencies (cf. Table 13).

For the immediate future the evaluation model can determine the level of investment required nationally to obtain the level of public waste treatment which is needed to meet general water quality objectives.

The approximate rate at which investment requirements are accumulating and the amount of the current accumulation of need are known. Thus a projection procedure is utilized to find the annual rate of investment that will sustain existing physical capital, meet expansion requirements, offset inflation, and eliminate the accumulation of investment requirements that currently exists (backlog).

The procedure used takes into account both the existing capital stock and the following variables which constitute elements of the investment activity: growth, recapitalization, and the backlog of accumulated demands. The procedure also assumes a constant rate of inflation and a constant rate of growth.

Recapitalization, capital in place, and backlog are derivatives of investment. Recapitalization is calculated as 2.9 percent of capital in place in any year. Growth needs are calculated to amount in any year to 3.3 percent of capital in place. To the extent that the investment covered growth requirements, the value is transferred to capital in place. Values exceeding available investment are added to the backlog of unmet needs. The backlog itself is reduced by any amount that available investments exceed recapitalization and growth elements, or increased as prior demands on a hypothesized investment exceed the amount of available investment.

TABLE 13

EVALUATION OF CAPITAL IN PLACE AND OF DEFINED NEEDS

	Value of Works in Place ($000,000)		Value of Needed Works	
	1968	1971	1968	1971
Alabama	191.8	224.1	122.8	77.3
Alaska	1.5	5.0	8.3	22.0
Arizona	62.9	99.9	20.4	31.0
Arkansas	147.7	183.7	44.6	17.0
California	1061.4	2060.7	377.2	530.3
Colorado	228.9	428.9	43.2	58.6
Connecticut	128.8	181.3	73.4	2.7
Delaware	34.5	19.0	3.5	3.5
Dist.of Columbia	46.4	525.1	28.2	4.0
Florida	431.1	456.3	48.4	238.8
Georgia	281.8	303.9	123.8	201.4
Hawaii	23.2	26.1	25.9	25.0
Idaho	80.0	159.4	33.5	14.5
Illinois	686.1	921.3	194.9	78.5
Indiana	431.9	999.9	139.2	151.4
Iowa	285.9	305.5	44.3	34.4
Kansas	254.6	318.3	82.5	64.7
Kentucky	193.9	267.2	16.3	28.1
Louisiana	193.3	166.6	79.2	41.3
Maine	24.7	26.6	91.8	30.2
Maryland	121.9	478.2	28.3	57.8
Massachusetts	141.0	195.4	209.2	50.6
Michigan	348.2	626.5	135.7	371.5
Minnesota	283.2	415.9	54.4	155.8
Mississippi	151.7	149.9	50.0	44.6
Missouri	316.0	335.0	148.8	87.5
Montana	75.5	76.4	22.6	18.6
Nebraska	171.1	194.3	38.2	15.2
Nevada	40.8	76.4	17.0	5.1
New Hampshire	22.5	23.7	61.5	10.8
New Jersey	420.1	379.7	162.0	54.3
New Mexico	98.8	119.9	10.2	24.4
New York	801.0	1015.2	276.0	578.6
North Carolina	342.7	401.7	101.7	73.5
North Dakota	77.8	76.4	6.6	14.8
Ohio	668.9	1205.2	229.9	296.2
Oklahoma	236.9	332.1	31.7	33.5
Oregon	171.7	328.9	64.2	36.2
Pennsylvania	585.4	789.5	362.3	231.3
Rhode Island	52.6	82.8	22.9	9.8
South Carolina	156.1	161.7	66.9	59.4
South Dakota	81.0	72.9	13.8	.4
Tennessee	232.5	328.6	71.8	79.6
Texas	882.0	1440.7	161.5	459.2
Utah	120.8	191.5	28.0	41.5
Vermont	28.7	32.3	40.8	13.0
Virginia	229.4	309.6	65.6	147.7
Washington	197.6	448.4	90.1	98.7
West Virginia	102.0	157.2	74.9	31.5
Wisconsin	350.9	628.2	124.5	187.5
Wyoming	52.7	53.2	8.8	4.4
Guam	0.	0.	0.	0.
Puerto Rico	47.1	68.5	32.6	132.8
Virgin Islands	0.	0.	3.7	0.
TOTAL	12392.0	18874.5	4417.5	5080.5
TOTAL	15316.5[1]	18874.5	5460.0[1]	5080.5

[1]1971 Dollars.

The evaluation model is seen to be a more accurate indicator than a survey approach of investment needed in the municipal waste treatment area because it corresponds to both what has happened in the past and what might reasonably be expected to occur in the future. However, the weaknesses of demand modeling should be noted. It fails to reflect some components of demand which are not known precisely enough to distinguish qualitative shifts readily. Such shifts are the ratio of plant costs to ancillary costs; depreciation rates for interceptors, outfalls, pumping stations; and the loss of sunk capital through accelerated replacement and inadaptability of existing plants to higher degrees of treatment. Also, the composition of the backlog requirements, if not fully reported in the Municipal Waste Inventory, would bias the backlog calculation.

Survey Technique

The 1971 survey of municipalities was conducted to update EPA estimates of the scope and cost of construction of municipal waste treatment facilities, planned through 1976, which are needed to meet current water quality standards implementation schedules or other current standards or enforcement requirements.

The survey was directed to 2294 municipalities whose population was greater than 10,000 persons or whose facilities were serving more than 10,000 persons. The response rate was 95.5 percent.

In addition to providing the cost estimate of planned construction activity, the responding municipalities were requested to provide such information as:

- the reason for planning the reported construction,
- the type of facilities to be constructed,
- the level of treatment to be achieved,
- the percentage of the effluent attributable to industrial waste,
- expected dates for operation to begin,
- the method upon which user charges are based,
- additional employee requirements resulting from the planned construction.

The survey approach is a potentially useful guide to short-term (1-2 year) investment intentions. However, community cost estimates become unreliable in the long-term situation and fail to indicate probable construction activity.

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